RAYTHEON

OPERATION OF DECADE COUNTER TUBES

OPERATION OF DECADE COUNTER TUBES

In the interest of familiarizing circuit designers with Raytheon decade counter tubes, this handbook has been prepared with emphasis on theory of operation and general descriptive information. Included also are a number of circuit designs utilizing the valuable characteristics of these tubes and offering suggestions as to further applications. In addition, data is contained on the electrical characteristics of Raytheon's family of decade counter tubes.

The data contained herein is compiled as a service to the field and is believed to be accurate and reliable. Raytheon Company assumes no liability for information on applications and data derived from this book.

RAYTHEON

by Tomasz Jedrzejewicz, Field Applications Engineer, INDUSTRIAL COMPONENTS DIVISION

Raytheon decade counter tubes are gas-filled, cold-cathode, glow discharge, bi-directional stepping devices, capable of operation at frequencies up to 100 kilocycles/sec. They are characterized by very long life, low current requirements, relatively few external components necessary for proper operation, both an electrical and a visual readout, and low operating temperature. These characteristics make them very useful as counters in such applications as radiation measuring equipment, timers, programmable counters and scalers, sorting apparatus, and many others. In these applications they can be used as scale-of-ten counters or as devices capable of operation at any desired preset scale.

General

The tube consists of thirty identical rod-shaped electrodes equally spaced around a circular disc anode. One may consider an electrical analog of this configuration to consist of thirty glow-discharge diodes with a common anode. These electrodes are divided into three equal groups.

Group 1. This group of electrodes is referred to as the cathode group and all cathodes are assigned a number, starting with "one." Thus we have K1, K2, K3, . . . K9, K0.

Group 2. All electrodes in this group are tied together inside the tube and brought out to a single socket terminal. This group is referred to as the Guide No. 1 (G1) group of electrodes.

Group 3. As in Group 2, all Group 3 electrodes are tied together inside the tube and brought out to a single socket terminal. This group is referred to as the Guide No. 2 (G2) group of electrodes.

Description and Theory of Operation

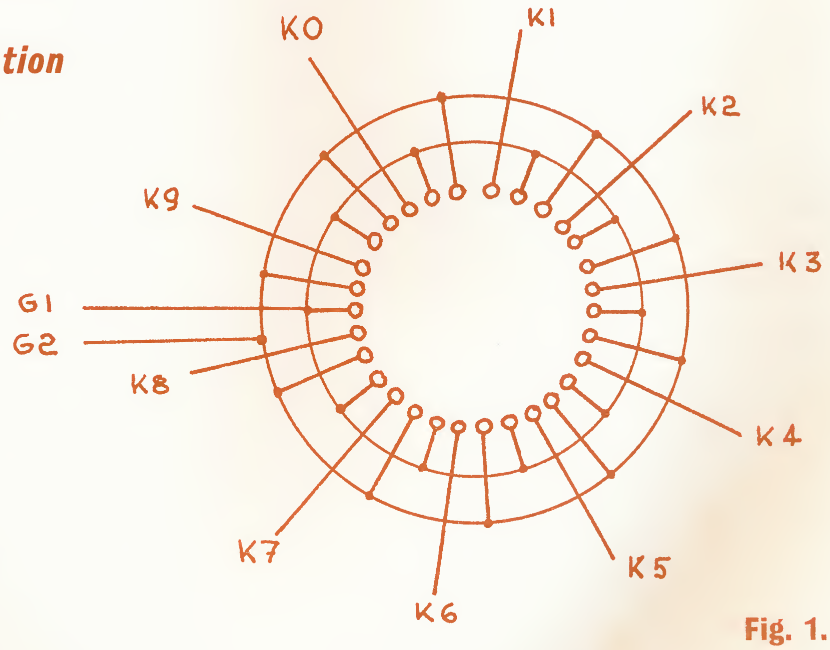
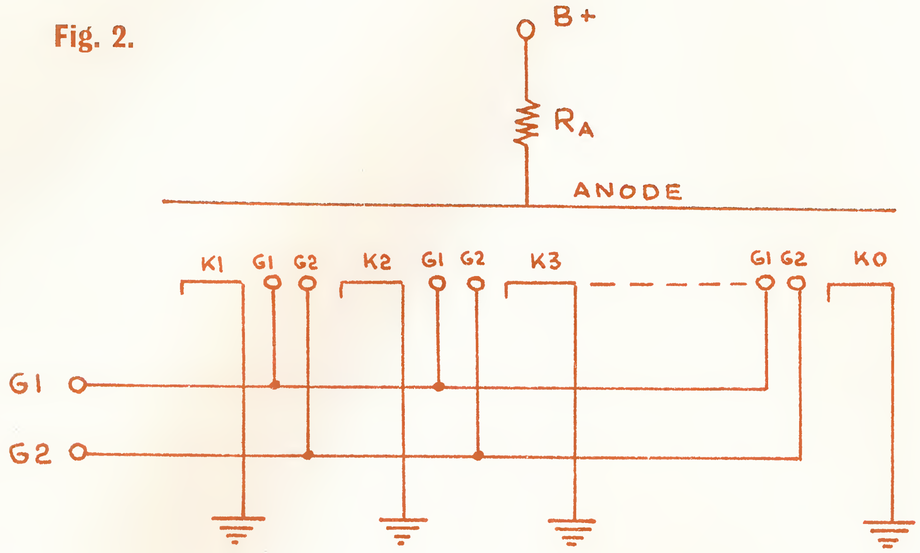


Fig. 1.

All of these electrodes are intermeshed in a cyclic order around the anode as shown in Figure 1.

Fig. 2.



The guide electrodes are necessary to transfer the glow from one cathode to another. The operation of the tube can be best described by considering the circuit in Figure 2.

When a sufficiently high voltage is applied to the anode through an appropriate current limiting resistor, the gas in the interelectrode space becomes ionized and a glow forms around one of the cathodes. The selection of the cathode around which the glow will form is a completely random process depending only on the presence of ionized particles in the anode-cathode gap. These ionized particles are produced by either stray radiation or previous ionizations. Once a glow is established and current begins to flow, the voltage across the tube drops to the sustaining voltage (tube drop) and the remaining voltage is dropped across the current limiting resistor.

Due to the close proximity of guides and cathodes, the ionized area surrounding the conducting cathode extends so that it partially envelops both adjacent guides. The visual glow, however, is strictly confined to the immediate area of the conducting cathode and the anode area directly opposite this electrode. This, so-called, pre-ionized condition reduces the breakdown voltage of the adjacent guide-anode gaps to a value only slightly higher than the normal tube drop. If G1 is made negative with respect to the conducting cathode, for example, −35 volts, then the glow will transfer itself to this negative guide. The reason for this transfer is that positive ions in the gap are attracted by the negative potential on the guide.

If we apply the same negative voltage to G2, at the same time maintaining this negative voltage on G1, the glow on G1 remains unchanged, since we have not introduced any special force to pull the glow away from G1. However, when the voltage is removed from G1, the glow will transfer to G2 since the latter is the most negative electrode in the immediate vicinity. Removing the voltage from G2 will cause the glow to transfer to the next cathode since this is the nearest electrode which is returned to ground.

Hence, we see that four successive steps are required to transfer the glow from one cathode to another:

1. One set of guides is brought to a negative potential, with respect to the conducting cathode, to transfer the glow to this adjacent guide.

2. After the glow establishes itself on the first guide, the voltage on the second guide is brought to the same negative potential.

3. The voltage on the first guide is now removed to transfer the glow to the second guide.

4. After the glow establishes itself on the second guide, its voltage is removed to transfer the glow to the next cathode.

This process suggests that pulse techniques can be used effectively to transfer the glow around the tube. Two negative pulses, displaced in time by some finite amount, can be applied to G1 and G2 in succession, thus, transferring the glow from cathode to G1 to G2 and finally, to the next cathode. This displacement of the two pulses or overlap is necessary to eliminate a chance for erratic transfer.

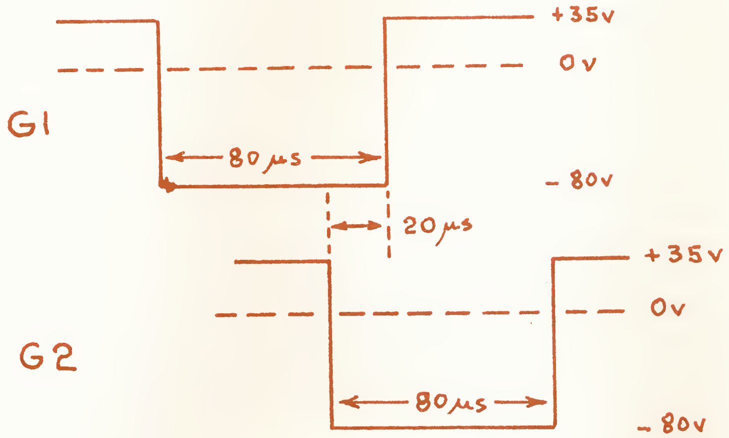
Typical pulse waveforms necessary for proper operation of these tubes are shown in Figure 3.

The +35 and +45 volt portions of the pulse waveforms in Figure 3 represent positive bias on the guides. This bias is very essential for proper operation of the tube and will be explained in detail in later paragraphs.

The rise and fall times of these pulses are unimportant as long as the amplitudes, overlap, and duration are within the specified limits. When counting at high speeds, however, one should make every effort to use as clean a waveform as possible.

The phase relationship between the G1 and G2 pulses should be controlled so that a slight overlap between the pulses exists at all times. If this overlap is too small or if there is a finite time between the end of the G1 pulse and the beginning of the G2 pulse, then the glow on G1 may return to the previous cathode instead of transferring to the

Fig. 3a



Low-Speed Types

next guide. If the overlap is too large, as for example, when both pulses are applied almost simultaneously, the glow may not transfer at all. The tube requires a specific minimum time for the glow to establish itself on a particular electrode. When this minimum time does not elapse, the glow will remain on the cathode. Hence, pulses of 1000 microseconds or greater duration can be used for transferring the glow as long as the minimum pulse width requirement is satisfied. For example, type CK6476 has a minimum pulse width of 60 microseconds; therefore, if a 500 microsecond pulse is used, the overlap can be as much as 440 microseconds and reliable operation may still be expected.

It is not necessary to use two pulse generators to drive the tubes. One may use a single pulse of proper amplitude and duration, feed that pulse directly to G1 and at the same time feed it to G2 through a proper integrating network. Typical example is shown in Figure 4.

Biasing of the guides is extremely important to achieve proper operation of the tube. It is generally desirable to bias the guides at least 35 volts positive, with respect to the cathodes. This condition enhances the initial establishment of the glow on one of the cathodes, since the anode to cathode voltage is greater than the anode to guide voltage. The most important reason for this positive bias, however, is to drive the glow from G2 to the next cathode immediately after the pulse on G2 has decayed. As soon as the anode current flows through the cathode resistor, positive bias is opposed by the drop across this resistor, thus effectively lowering the positive bias and making it easier for the glow to transfer to G1 upon the arrival of the next pulse.

An electrical output can be obtained from the main cathodes by inserting a resistor in each cathode. A voltage will be developed across this resistor whenever the glow transfers from G2 to this cathode. The width of this output pulse is equal to the input pulse width minus the time the glow is on the guides.

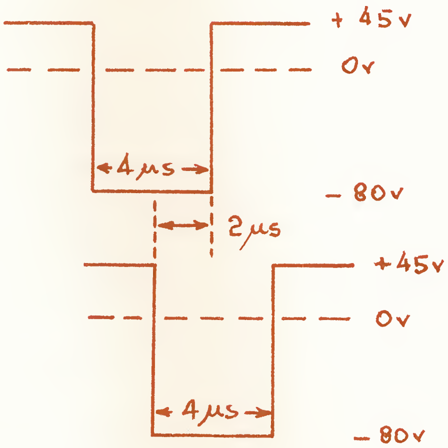


Fig. 3b

High-Speed Types

Counter tubes can be arranged in cascade to extend the scale of counting. For example, four tubes in cascade can be used to register 10,000 input pulses. When operating tubes with this configuration, it is necessary to add an amplifier-driver stage between each pair of counter tubes, since the output of the counter tube is of the wrong polarity (positive) and does not have enough amplitude to drive the next stage.

A counter tube can be made to operate in either direction, enabling the tube to add and subtract. In order to make the tube change its direction of counting, it is necessary to reverse the input pulses; that is, G2 must receive the pulse before G1. Using proper circuitry, it is possible to set up a chain of these tubes for random add-subtract operations.

In general, when designing counter tube circuitry, the following points should be observed:

1 Positive bias on the guides should be included in all stages.

2 Drive pulse amplitudes should meet or exceed those specified on the data sheet. It is not uncommon to use even 140 volt pulses to drive the tube.

3 The pulse width and phase displacement should never be smaller than those specified on the data sheet. Whenever long standby periods are encountered it is important to use as wide a pulse and as large a phase displacement as the counting speed will allow.

4 Anode current should never exceed the design maximum value. If long standby periods are encountered, the anode current should be near the lower limit. This will tend to minimize sputtering of the cathode material on the adjacent electrodes and elements. Sputtering of cathode material lowers the tube drop on the cathode that loses this material and increases the tube drop on the guides upon which this material is deposited. Such changes in surface condition of the electrodes may ultimately result in inability of the tube to transfer the glow.

5 There is a definite limitation on the size of the cathode

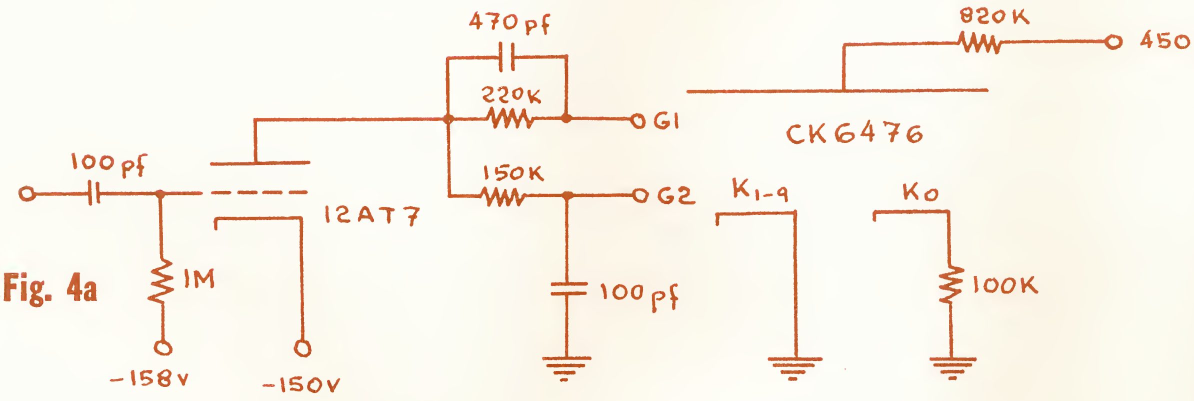


Fig. 4a

resistor. The voltage across the cathode resistors opposes the positive bias and if it should exceed this bias, instability may occur and the glow may jump to another cathode.

6 At counting speeds approaching 100 kilocycles/sec. all stray circuit capacitances should be minimized. The anode resistor should be mounted as close as possible to the anode terminal on the tube socket, preferably less than ½ inch away. Because the operation of the tube at these frequencies is very critical, a potentiometer should be used in the anode circuit to vary the current approximately 200 microamperes so that best operation can be chosen.

7 The tube should not be operated above the specified maximum ambient temperature. At elevated temperatures, the increased gas pressure inside the tube may change the maximum counting speed.

8 The anode supply voltage may be as high as 700 or 800 volts as long as the maximum anode current is not exceeded. High voltage and a high anode resistor value tend to minimize variations in tube current due to the differences in individual tube voltage drops.

Resetting decade counter tubes to any desired cathode can be easily accomplished by several means. All guides and cathodes, excepting that cathode to which the glow is to be reset can be lifted off ground momentarily. This forces the glow to establish itself on the only cathode that is returned to ground.

A more common way is to reset the tube by means of a pulse applied to the cathode to which the glow is to be transferred. The pulse should have an amplitude of approximately —150 volts and a width no less than that specified on the data sheet. When resetting a chain of counter tubes, the first tube should be reset to the "zero" cathode; the rest of the tubes should be reset to cathode number nine. The resulting pulse from the first tube will carry down the chain, resetting the rest of the tubes to the "zero" cathode.

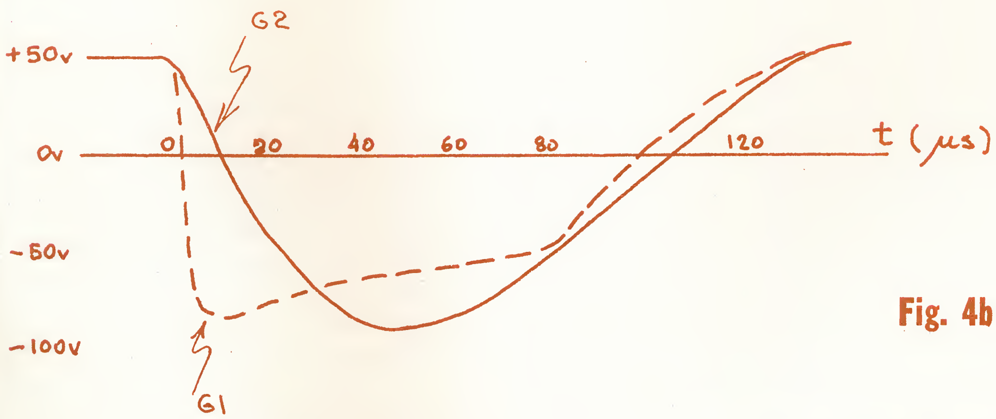
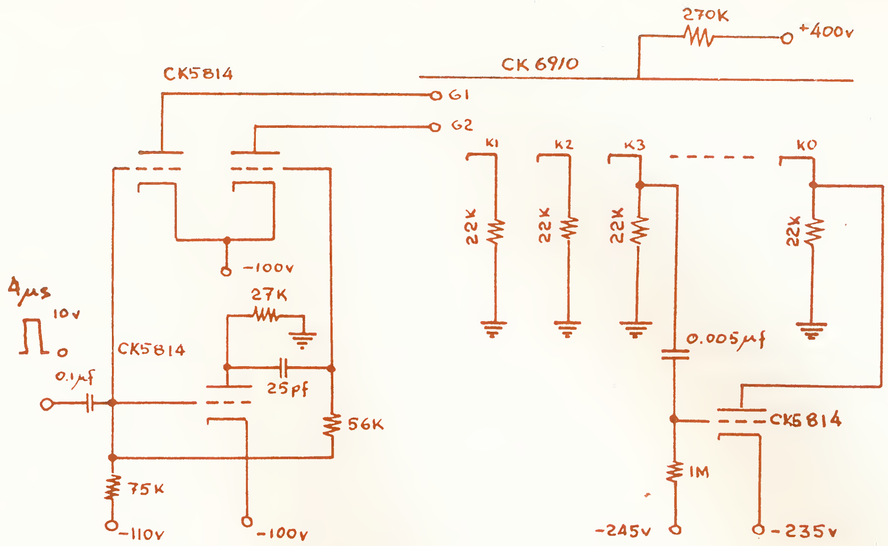


Fig. 4b

G1 and G2 Waveform



CK6910 Frequency Divider

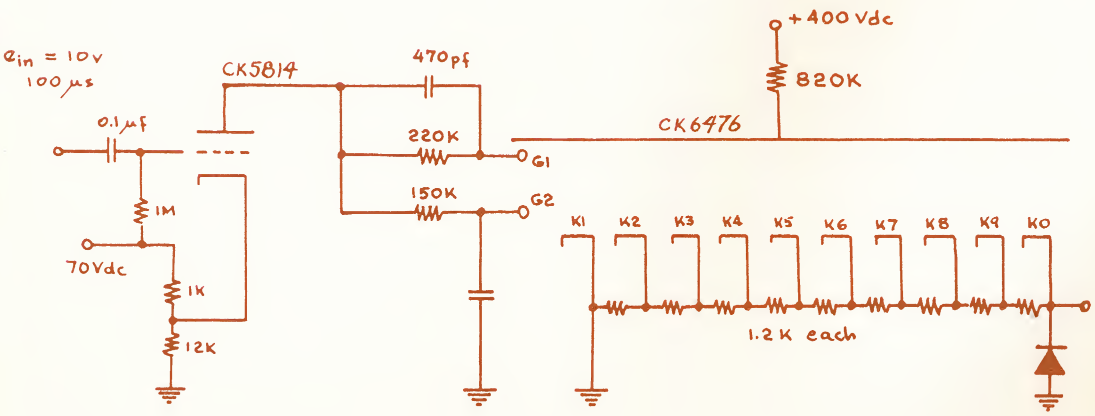
This circuit can be used to divide the input frequency by any digit from 2 to 10. When dividing by 2 and 5 the reset network is not necessary since division by 2 can be accomplished by taking the output from cathodes 2, 4, 6, 8 and 0 and division by 5 is performed by taking the output from cathodes 5 and 0.

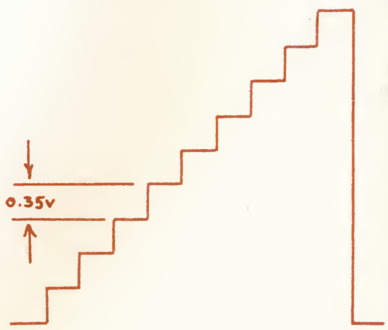
The above circuit will work quite well at frequencies up to 70 kc/s. Above this frequency the operation is not too reliable unless the circuit is well optimized.

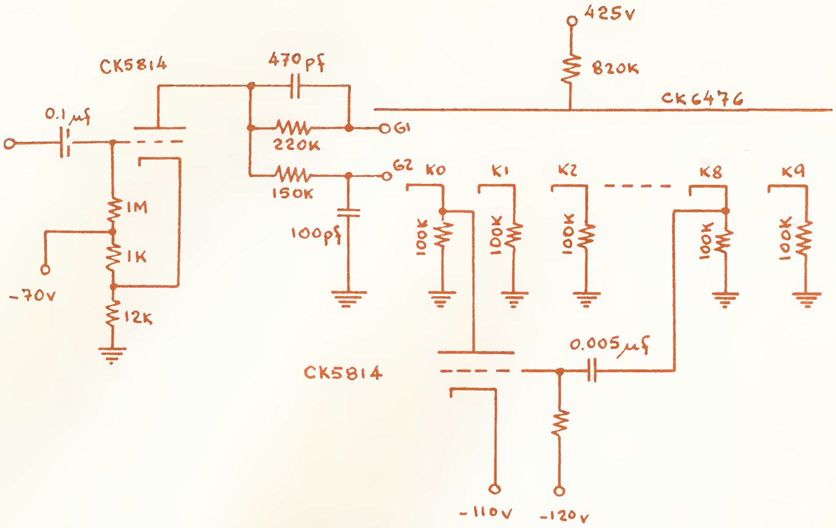
CK6476 Step Generator

This circuit can be used to generate a positive going step or staircase waveform. With the arrangement as shown, nine voltage steps are produced with approximately 0.35 volts/step. Increasing the cathode resistor will increase the amplitude of each step although some non-linearity will occur so that the steps near the end of the waveform will be smaller than those in the beginning. As the operating frequency is increased above 1 kc/sec. some rounding of the individual steps will occur and at frequencies approaching the maximum counting frequency the output waveform loses most of its usefulness.

Typical waveform at an input frequency of 150 cps is shown below.







CK6476 Frequency Divider

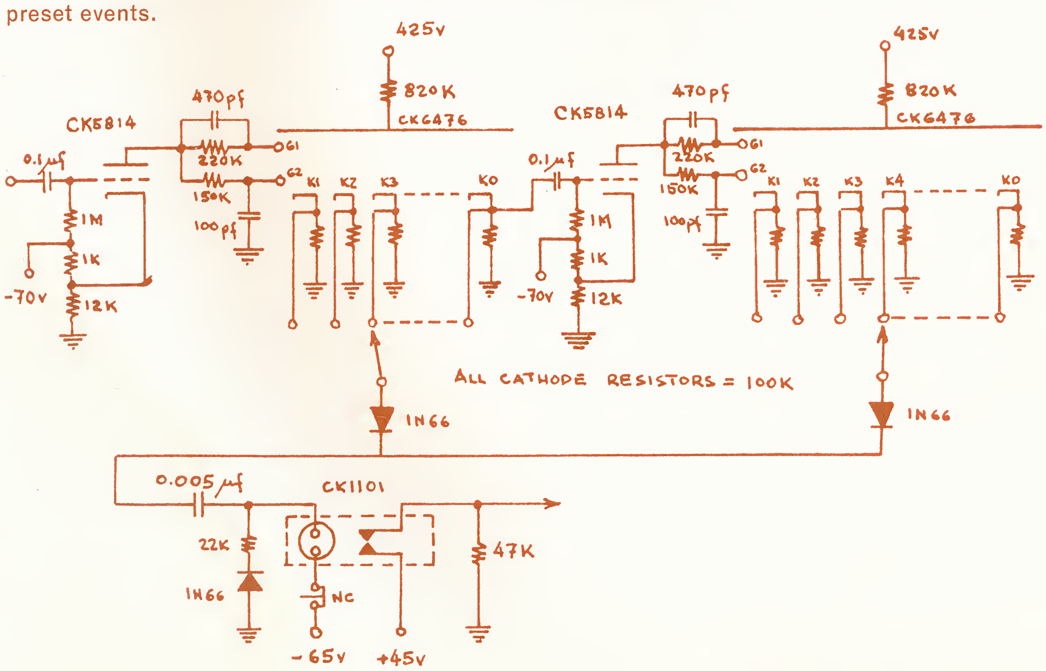
The above circuit shows frequency division by eight. The output from cathode eight (K8) is fed to an amplifier which resets the glow to cathode zero (K0), thus omitting K9. The counter continues to count from K0 to K8 and back to K0 without missing an input pulse, thus providing very accurate frequency division.

The counter can be preset to divide by any desired number simply by taking the output from any cathode and using it to reset the glow. The tube will count up to this number only, omitting all subsequent cathodes.

CK6476 Preset Counter

With switches in positions as shown an output can be obtained when the counter reaches the count of 43. At coincidence, the CK1101 Raysistor switches "on" and remains "on" until the —70 volt line is interrupted. The Raysistor can be replaced by a thyratron and a relay if the counter is to control a large current.

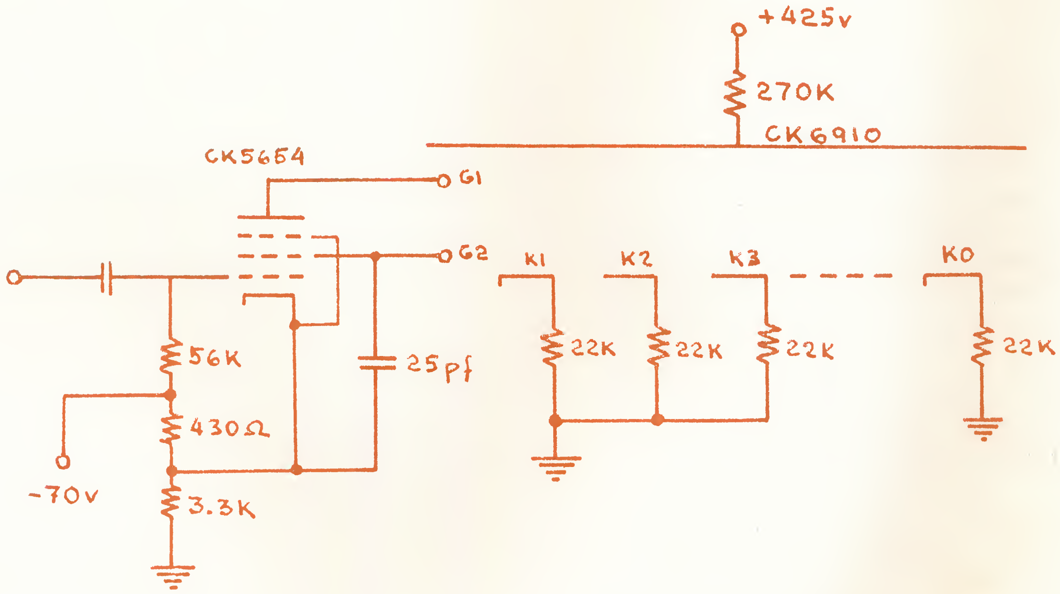
By adding more switches and coincidence networks it is possible to extend the capability of this circuit to any number of preset events.



50kc Drive Circuit

A positive pulse applied to the grid of the CK5654 will cause plate and screen currents to flow. The screen capacitor will maintain the voltage on the screen permitting the plate voltage to drop to a value close to that of the cathode voltage. The glow will then transfer to G1. After the plate has bottomed, a large current transfers to the screen, discharging the screen capacitor.

When the positive pulse is removed from the grid, the tube cuts off and the plate voltage begins to rise forcing the glow to transfer to G2. As soon as the capacitor recharges the positive bias on G2 forces the glow to transfer to the next cathode.



Technical Information

Decade Counter Tubes CK8262, 6476, 6476A, 6802, 6909, 6910 and 7978

TUBE TYPE NUMBER:	6476	6476A	6802	7978	6909	6910	8262	Units

MECHANICAL DATA:

Mounting Position ▲	Any	Any	Any	Any	Any	Any	Any	
Zero Position Cathode Number	0	0	0	0	0	0	0	
Aligned with Pin No.	12±10°	12±10°	6±10°	8±10°	6±10°	12±10°	8±10°	
Bulb	T11	T11	T9	T9	T9	T11	T9	
Base	Modified Duo-decal	Modified Duo-decal	Octal 8-pin Inter. Shell	13-pin	Octal 8-pin Inter. Shell	Modified Duo-decal	13-pin	
Number of Output Cathodes	10	10	4	10	4	10	10	

ABSOLUTE RATINGS:

Total Anode Current ⧫								
Maximum	0.6	0.6	0.6	0.6	0.8	0.8	0.8	mA
Minimum	0.3	0.3	0.3	0.3	0.6	0.6	0.6	mA
Anode Supply Voltage ⊕								
Maximum	700	700	700	700	800	800	800	Vdc
Minimum	350	350	350	350	400	400	400	Vdc
Transfer Voltage								
Maximum	140	140	140	140	140	140	140	Vdc
Minimum	35	35	35	35	35	35	35	Vdc
Voltage between Electrodes, excluding Anode, Maximum	140	200	140	200	140	140	200	v
Ambient Temperature								
Maximum	+60	+60	+60	+60	+60	+60	+60	°C
Minimum	−55	−55	−55	−55	−55	−55	−55	°C
Input Frequency Range	0-5	0-5	0-5	0-5	0-100	0-100	0-100	Kcps

TYPICAL OPERATING CONDITIONS:

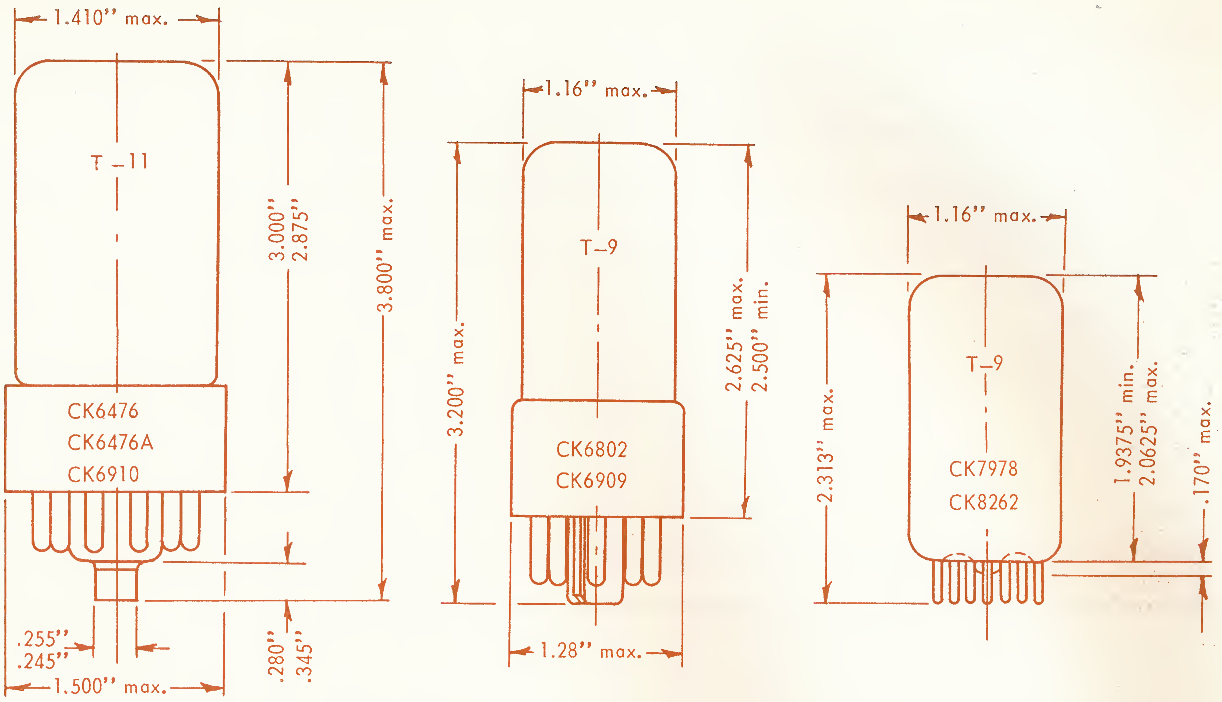
Anode Supply Voltage	350-450	350-450	350-450	350-450	400-500	400-500	400-500	+Vdc
Nominal Tube Drop	187	187	187	190	235	235	235	Vdc
Guide Bias (Minimum)	+35	+35	+35	+35	+45	+45	+45	Vdc
Min. Square Double Pulse Drive Amplitude*	−75	−75	−75	−75	−85	−85	−85	v
Min. Square Double Pulse Duration*	60	60	60	60	4	4	4	μsec
Forced Reset Pulse Amplitude, Min.	−120	−120	−120	−120	−120	−120	−120	v
Reset Pulse Width, Min.	50	50	50	50	4	4	4	μsec
Double Pulse Drive Overlap	10(nom)	10(nom)	10(nom)	10(nom)	2(min.)	2(min.)	2(min.)	μsec
Cathode Load Resistor (Max.)	150	150	150	150	50	50	50	Kohm

▲ Visual Readout from top of tube

⧫ When high speed types 6909, 6910 and 8262 are operated in the range of 50 to 100 Kcps, each tube should be provided with a series potentiometer to vary the average plate current a minimum of 100 μAdc above and below the specified center value, and then adjusted for optimum operation.

⊕ To compute anode resistor, subtract the nominal tube drop from the supply voltage used and then divide by the desired operating current.

* Two separate pulses, with slight overlap, must be maintained. Pulse duration applies to single pulse.



TERMINAL CONNECTIONS:

PIN NO.	6476	6476A	6802	7978	6909	6910	8262
1	Cathode 0	Cathode 0	Common Cathode	Anode	Common Cathode	Cathode 0	Anode
2	Cathode 9	Cathode 9	Cathode 5	Cathode 5	Cathode 5	Cathode 9	Cathode 5
3	Cathode 8	Cathode 8	Guide 1	Cathode 4	Guide 1	Cathode 8	Cathode 4
4	Cathode 7	Cathode 7	Anode	Guide 2	Anode	Cathode 7	Guide 2
5	Cathode 6	Cathode 6	Guide 2	Cathode 3	Guide 2	Cathode 6	Cathode 3
6	Cathode 5	Cathode 5	Cathode 9	Cathode 2	Cathode 9	Cathode 5	Cathode 2
7	Cathode 4	Cathode 4	Cathode 0	Cathode 1	Cathode 0	Cathode 4	Cathode 1
8	Cathode 3	Cathode 3	Cathode 8	Cathode 0	Cathode 8	Cathode 3	Cathode 0
9	Cathode 2	Cathode 2		Cathode 9		Cathode 2	Cathode 9
10	Cathode 1	Cathode 1		Guide 1		Cathode 1	Guide 1
11	Guide 2	Guide 2		Cathode 8		Guide 2	Cathode 8
12	Guide 1	Guide 1		Cathode 7		Guide 1	Cathode 7
13				Cathode 6			Cathode 6
Center Post	Anode	Anode				Anode	

INTERELECTRODE CAPACITANCES: (NOMINAL)

TYPES:	6910 6476, 6476A	6802 6909	7978 8262
Any Cathode To All Other Elements	4.2	1.8	1.6
Guide 2 To All Other Elements	10.0	9.0	8.0
Guide 1 To All Other Elements	10.0	8.0	8.0
Common Cathode To All Other Elements	—	6.5	

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NYC: Wisconsin 7-6400
Area Code: 212

1500 Kings Highway
Haddonfield, N.J.
Tel: HAzel 8-1800
Area Code: 609

2360 James St.
Syracuse, N.Y.
Tel: HOward 3-9141
Area Code: 315

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Area Code: 312

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Dallas, Texas
Tel: LAkeside 6-7921
Area Code: 214

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225 North Van Ness Ave.
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Area Code: 213

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TECHNICAL INFORMATION SERVICE

Technical Information

CK1084

NUMERICAL INDICATOR

Raytheon Tube Type CK1084 is a digital, in-line, miniature indicator tube designed for operation from electromechanical and mechanical switches, from cold cathode tubes, or from transistor circuits. This tube features side-viewing and is available with numerals 0 to 9. Offering the advantage of in-line display, the CK1084 also features low power consumption, reliability and convenience of usage. The CK1084 is designed and processed for ultra long life performance.

ELECTRICAL DATA

ABSOLUTE MAXIMUM RATINGS:

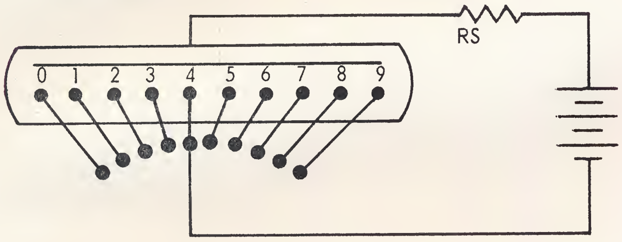
		Units
Ionization voltage, maximum	180	Vdc
Supply voltage, minimum, See Note 1	180	Vdc
Cathode current max.	3.0	mA

TEST CONDITIONS (See Basic Circuit)

Supply voltage (Ebb)	180	Vdc
Series resistor (Rs)	18	Kohms
Cathode current (Ik)		
Minimum	1.5	mA
Maximum	3.0	mA

TYPICAL OPERATING CONDITIONS:

BASIC CIRCUIT

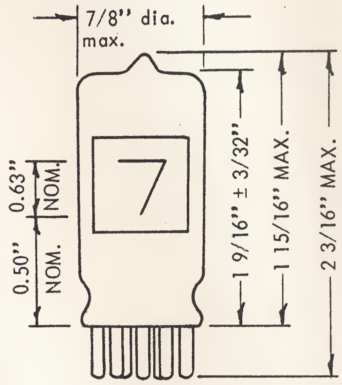


Ebb	Rs
180 Vdc	18K ohm
250 Vdc	56K ohm
300 dc	82K ohm

MECHANICAL DATA

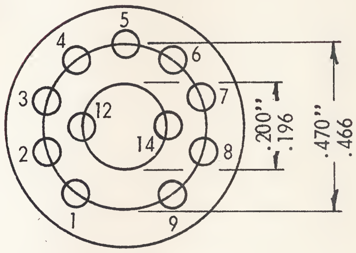
Envelope. . . T6½ Glass JEDEC 6–2
Base . . . . Miniature button 11–pin
Mounting Position. . . . . . . .Any

OUTLINE



BASING

FRONT



BOTTOM VIEW

APPLICATION NOTES

Note 1: The minimum supply voltage should be 180 volts. However, the use of the highest available supply voltage with a suitable series resistor to maintain cathode current within the specified limits is recommended. This will reduce variations in current between individual tubes and numerals, initially and during life.

TERMINAL CONNECTIONS

1	K0
2	K9
3	K7
4	K6
5	K1
6	K5
7	K4
8	K2
9	Anode
12	K8
14	K3

Tubes may be used with special 11–pin miniature Raytheon sockets.

Special types with characters as required for special use can be designed and manufactured on request.

These data identify a particular developmental tube design. The type designation or the descriptive data may be subject to change or abandonment.

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TECHNICAL INFORMATION SERVICE

Technical Information

CK1085

CHARACTER INDICATOR

Raytheon Tube Type CK1085 is a special, single plane, miniature character indicator tube designed for operation from electromechanical and mechanical switches, from cold cathode tubes, or from transistor circuits. This tube is designed for side–viewing and displays the characters "+" and "–". The CK1085 features low power consumption, reliability and convenience of usage, and is designed and processed for ultra long life performance.

ELECTRICAL DATA

ABSOLUTE MAXIMUM RATINGS:

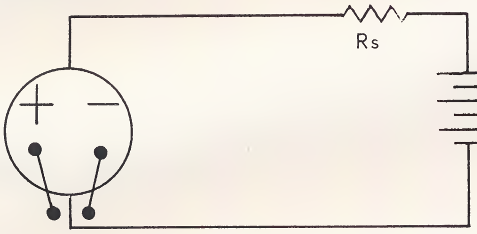
		Units
Ionization voltage, maximum	180	Vdc
Supply voltage, minimum, See Note 1	180	Vdc
Cathode current max.	3.0	mA

TEST CONDITIONS (See Basic Circuit):

Supply voltage (Ebb)	180	Vdc
Series resistor (Rs)	18	Kohms
Cathode current (Ik)		
Minimum	1.5	mA
Maximum	3.0	mA

TYPICAL OPERATING CONDITIONS:

BASIC CIRCUIT



Ebb	Rs
180 Vdc	18K ohm
250 Vdc	56K ohm
300 dc	82K ohm

APPLICATION NOTES

Note 1: The minimum supply voltage should be 180 volts. However, the use of the highest available supply voltage with a suitable series resistor to maintain cathode current within the specified limits is recommended. This will reduce variations in current between individual tubes and characters, initially and during life.

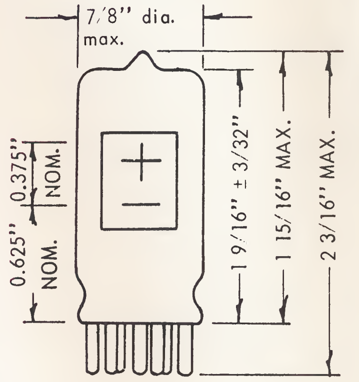
Other special types with characters as required for special use can be designed and manufactured on request.

These data identify a particular developmental tube design. The type designation or the descriptive data may be subject to change or abandonment.

MECHANICAL DATA

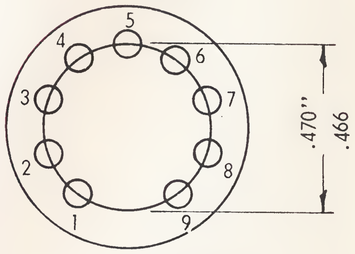
Envelope	T6½ Glass JEDEC 6–2
Base	Miniature button 9–pin JEDEC E9–1
Mounting Position	Any

OUTLINE



BASING

FRONT



BOTTOM VIEW

TERMINAL CONNECTIONS

1	NC
2	Plus (+) Sign
3	NC
4	NC
5	NC
6	NC
7	Minus (–) Sign
8	NC
9	Anode

NC – No Connection

Do not connect to NC pins.

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RAYTHEON

TECHNICAL INFORMATION SERVICE

Technical Information

CK1395P-

CATHODE RAY TUBE

The CK1395P– is a 24" rectangular cathode–ray tube which features magnetic major deflection and electrostatic minor deflection. The low–capacitance deflection design permits high speed character formation. Character positioning is accomplished magnetically. High resolution and high brightness are also major features of this tube type. The CK1395P– can be obtained with any of the JEDEC standard phosphors.

ELECTRICAL DATA

GENERAL CHARACTERISTICS:

Heater Voltage	6.3 volts
Heater Current at 6.3 Volts	.6 ± 10% amperes
Focusing Method	Electrostatic
Deflection Method	
Major: Deflection Angle Diagonal	90° Magnetic
Minor: Deflection	Electrostatic 2.5°

DIRECT INTERELECTRODE CAPACITANCES:

Cathode to All	6 pf
Grid No. 1 to All	9 pf
D1 to All	2.5 pf
D2 to All	2.5 pf
D3 to All	2.5 pf
D4 to All	2.5 pf

OPTICAL DATA

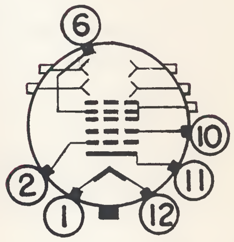
Screen	P31 Aluminized
Fluorescence	Green
Persistence	Medium
Face Plate (neutral gray) transmission	76%

MAXIMUM RATINGS: (Absolute Maximum Ratings)

Anode Voltage	18,000 Max. Volts
Focus Electrode	1,000 Max. Volts
Deflection Plate–to–Plate Voltage (MEAN = EA_2)	1,000 Max. Volts
Grid No. 2 Voltage	700 Max. Volts
Grid No. 1 Voltage	180 Max. Volts
Negative Bias Value	180 Max. Volts
Positive Bias Value	0 Max. Volts
Positive Peak Value	2 Max. Volts
EHK	± 180 Max. Volts
Grid No. 1 Circuit Resistance	1.5 Max. Megohms
Grid No. 2 Circuit Resistance	.1 Max. Megohm
Deflection Plate Circuit Resistance	5.0 Max. Megohms

MECHANICAL DATA

Overall Length	23" ± 1/4"
Bulb Number	J192A
Bulb Contact	Recessed
E. S. Deflection Contacts	Modified J1–22



BASING 12M
Base (6–63)

TERMINAL CONNECTIONS:

Pin 1	Heater
Pin 2	Grid #1
Pin 6	Focus Electrode
Pin 10	Grid #2
Pin 11	Cathode
Pin 12	Heater
Metal Cap	Anode

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CK1395P-

CATHODE RAY TUBE

TYPICAL OPERATING CONDITIONS:

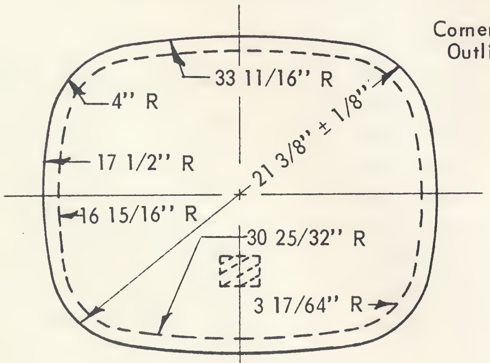
Anode Voltage	14,000 Volts
Focus Electrode Voltage	0 to 400 Volts
Grid No. 2 Voltage	400 Volts
Grid No. 1 Voltage (for cutoff)	–30 to –60 Volts
Light Output Note 1	50 FL
Dynamic Focus Voltage Required	Δ300 Volts
Resolution Note 1	.015"
Spot Position, Focused and Undeflected	.625" Radius of true center

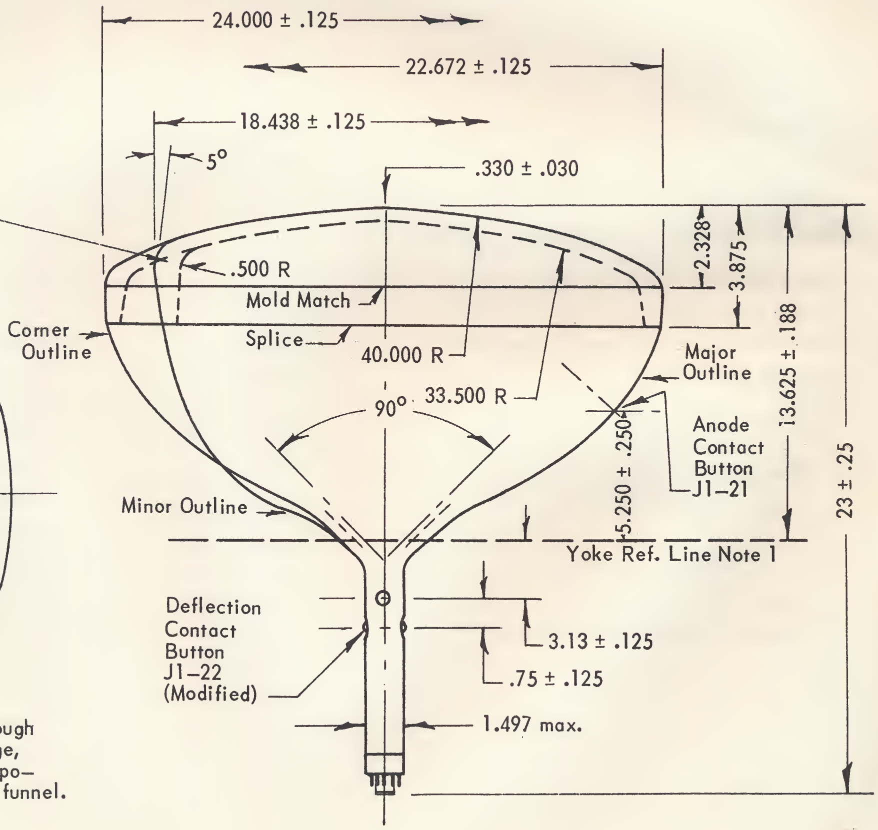
ELECTROSTATIC DEFLECTION CHARACTERISTICS:

D1, D2 Deflection Factor	230 Volts Per Inch Max.
D3, D4 Deflection Factor	230 Volts Per Inch Max.
Deflection (ES) Orthogonality	
D1, D2 to D3, D4	± 1°
D1, D2 to Bulb Axes	± 3°
Maximum Useful Scan	
D1, D2	3/4"
D3, D4	3/4"

NOTE 1: Light output stated is at .5" per microsecond writing rate, refreshed 60 times per second. Line width stated is also under the same conditions.

Deflection Plate orientation with respect to faceplate





NOTE:
1. With the tube neck inserted through JEDEC No. 116 Ref. Line Gauge, the Ref. Line is determined by position where gauge will rest on funnel.

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RAYTHEON DISPLAY DEVICES DATA

RAYTHEON FILAMENTARY SUBMINIATURE TUBES

Over 90% of the filamentary tubes in operation today were made by Raytheon. Raytheon has pioneered in this area from the hearing aid tubes of the late 30's through wartime communication tubes. Present applications include portable communcation devices, portable survey meters, electrometers, computers and telephone distance speaking and recording instruments.

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Better quality control in the manufacturing process enables Raytheon to offer series regulators, high voltage rectifiers and low power transmitting types with greater efficiency and reliability. These non-microwave power tubes are characterized by higher voltage, higher power and higher temperature capabilities.

RAYTHEON DISPLAY DEVICES

Raytheon manufactures over sixty types of Industrial Cathode Ray and Storage Tubes. Cathode Ray types include Oscillographs, Radar Indicators, Video Recorders and Flying Spot Scanners. Storage Tubes are applicable when retention, scan-conversion and/or integration of signals is desired.

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